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ORIGINAL ARTICLE

Osteosynthesis of distal radius fractures with the Micronail®

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Abstract
Introduction The Micronail® is a minimally invasive intramedullar titanium locking screw fixation for two-part dislocated extra-articular fractures and average displaced intra-articular fractures.
Patients and methods In a retrospective study we analyzed the outcome of 20 distal radius fractures in 18 patients (17 female, mean age 78 years), which were treated by Micronail®. Average follow-up time was 4 months. We describe the operative technique. All fractures were classified according to AO guidelines. We studied the radiologic and clinical outcome.
Results According to the AO classification there were 12 A2, 3 A3, 1 B1, and 1 B3 fracture. Three patients had an antebrachii fracture. Mean American Society of Anesthesiologists (ASA) score was 2.4. Eight patients had associated lesions. Average operative time was 58 min. All fractures healed without major loss of alignment. There were two major complications: one patient developed a carpal tunnel syndrome and one device secondary dislocated. With the use of the Micronail®, we found no infections or complications due to the insertion of the osteosynthesis materials. Patients experienced good to excellent results, on an analogue scale, in function of their wrist from the procedure. All patients had a good range of motion of the operated wrist; the difference between their two wrists was maximal 10° in all directions.
Conclusion This intramedullary implant intends to minimize some of the disadvantages of other surgical options in the treatment of distal radius fracture; the Micronail® causes less tissue damage and has early load-carrying capacity. This minimally invasive technique seems suitable in selected, two-part dislocated extra-articular and average displaced intra-articular, distal radius fractures.

Keywords Osteosynthesis · Radial fracture · Micronail®

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Introduction

Fractures of the distal radius are a common problem. The incidence in The Netherlands is more then 10,000 each year [1]. Most of these fractures occur in the elderly, at an average age between 60 and 69 years [1]. Most times, distal radius fractures can be treated conservatively with, after repositioning if necessary, a splint for 1 week, followed by a circular cast for 3 or 4 weeks [2–4]. Operative treatment, however, has the advantage of anatomical fixation and early realized osteosynthesis, which results in early load-carrying capacity [5]. Operative treatment options include percutaneous pinning, external fixation, internal fixation with plates, and a combination [1, 2, 4–15]. These techniques are either percutaneous and instable, open or externally fixated. Currently, the operative technique of choice for most surgeons is open reduction and internal fixation with volar fixed-angle plating [16–20]. A new device combines the benefits of the different surgical

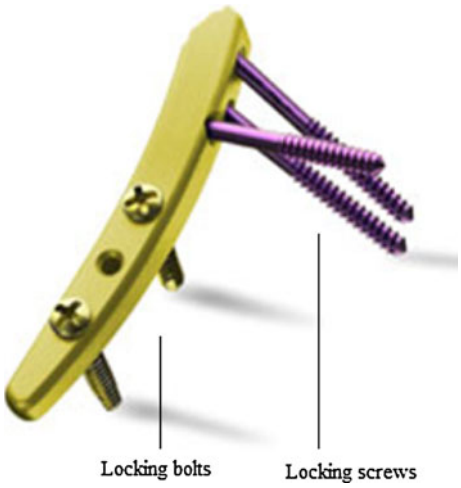

Fig. 1 The Micronail®

options: the Micronail® (Fig. 1). The Micronail® is a minimally invasive intramedullar titanium pin fixation for two-part dislocated extra-articular fractures and mildly displaced intra-articular fractures. The Micronail® supplies locking buttress screws support and reduces soft tissue complications due to its minimally invasive intramedullar surgical technique. In our hospital, we have used this intramedullary fixation method since 2007. This article describes a retrospective series of the first 20 consecutive wrist fractures in 18 patients. We describe the operative technique and evaluate clinical results and the radiologic outcome.

Patients and methods

Patients

From January 2007 to July 2008, there were 18 patients with 20 distal radius fractures treated by Micronail® fixation. Average age was 77.9 years (range 58–89 years). One (6%) patient was male and 17 were female. In 13 patients the wrist of the dominant hand was fractured. All fractures resulted from low-energy fall from standing height. Mean American Society of Anesthesiologists score (ASA classification) was 2.4 (range 1–3).

Operative technique

The patient's fractured wrist (Figs. 2a, 3a, 4a) is placed on a radiologic lucent arm support. Through closed reduction, using fluoroscopy, and temporary fixation with one Kirchner wire (1.6 mm K-wire) anatomical repositioning is achieved. An incision of 2–3 cm is made over the radial styloid process (Fig. 5a). Care must be taken not to harm

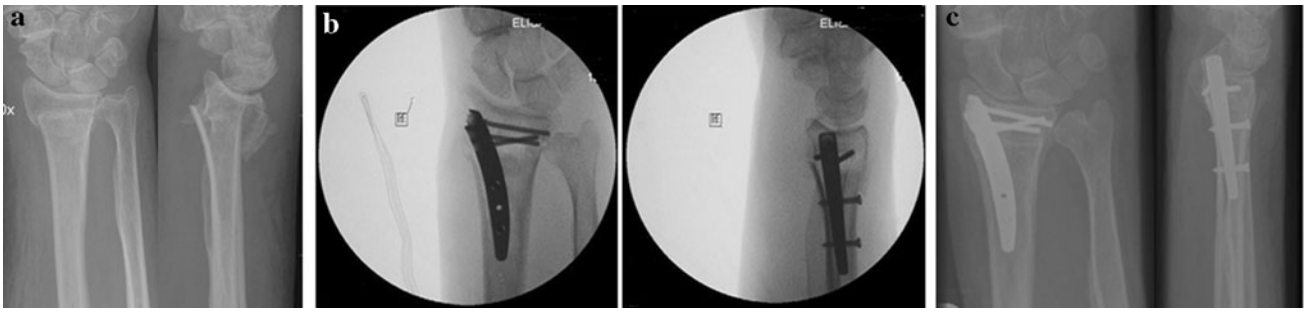

Fig. 2 **a** X-rays of the right wrist in a 78-year-old female, after a collapse; a two-part dislocated fracture can be seen. **b** Anteroposterior and lateral radioscopic view during surgery, after positioning the Micronail®. **c** Control X-ray of the wrist after 4 months of follow-up

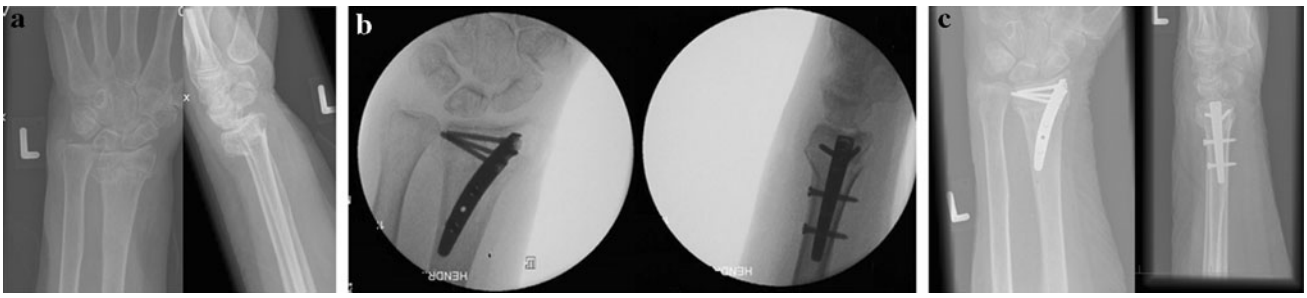

Fig. 3 **a** X-rays of the left wrist in an 88-year-old female, after she stumbled and fell on her left hand/wrist, showing an intra-articular fracture of the distal radius. **b** Anteroposterior and lateral radioscopic view during surgery, after positioning the Micronail®. **c** Control X-ray of the wrist after 3 months of follow-up

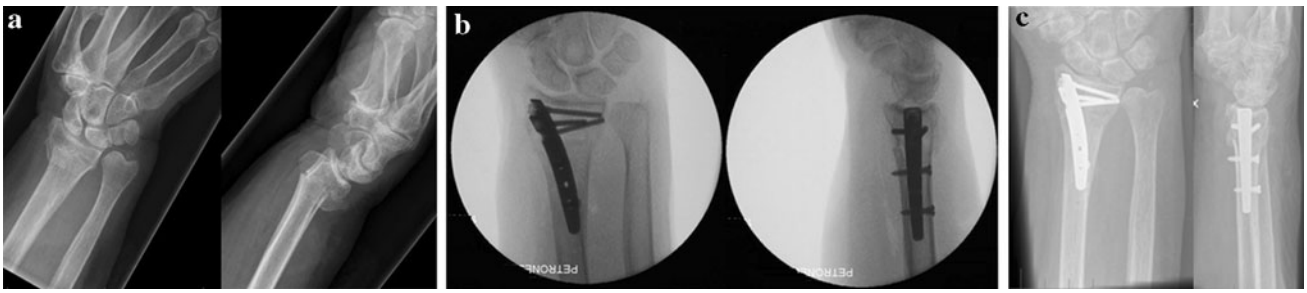

Fig. 4 **a** X-rays of the left wrist in an 85-year-old female, after she slipped on a carpet and fell on her hand. **b** Anteroposterior and lateral radioscopic view during surgery, after positioning the Micronail®. **c** Control X-ray of the wrist after 16 weeks of follow-up

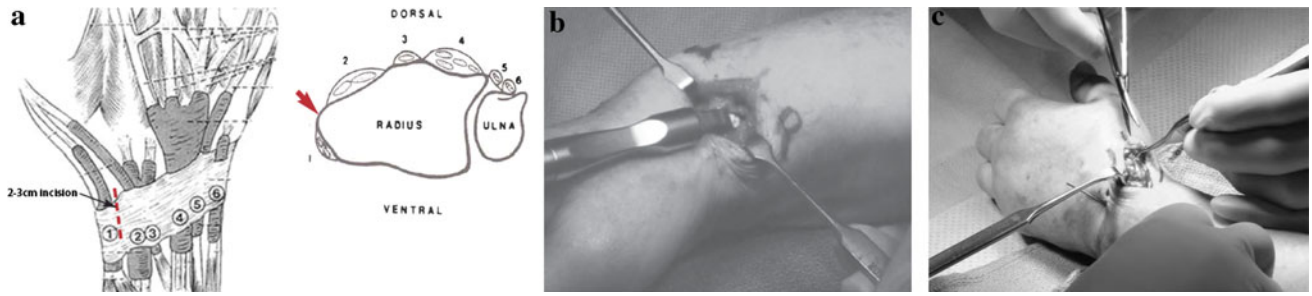

Fig. 5 **a** Anatomical approach for incision to place the Micronail®; care must be taken not to harm the superficial radial nerves. **b** Intraoperative approach for incision to place the Micronail® in the left wrist. The canulated drill is seen on the left side. **c** At the end of the procedure, after inserting the Micronail® and removing all devices, the wound is stitched

the superficial branches of the radial nerve, which run close to the site of incision. Minimal soft tissue dissection is performed to reach the periosteum, through dissecting the synovial sheaths of the extensor carpi radialis muscle and the combined sheaths of the abductor pollicis longus and extensor pollicis brevis muscle. Three millimeters proximal to the radioscaphoid joint, a 1.6-mm K-wire is inserted. To create a cortical window, a canulated drill is placed over the K-wire (Fig. 5b). Through the cortical window a broach is inserted into the medulla. To achieve the best position the wrist should be in ulnar deviation. The tip of the broach should always be in contact with the radial cortex. Afterwards, the broach is replaced by the Micronail®. Simultaneous K-wire fixation just proximal to the subchondral bone is achieved with assistance of fluoroscopy in lateral and anteroposterial direction. On the distal part of the Micronail® a guiding system for the distal locking screws is placed. Using this guiding system, three divergent screws can easily be placed into the distal radius, firmly attaching the distal fractured part with locking screws. With a proximal targeting guide attached to the distal guiding system, the Micronail® is fixed through two minimal incisions with two locking bolts to the proximal radius. Caution is required to prevent damage to the superficial radial nerve, which passes close to the site of incision. During the complete procedure, fluoroscopy is used eight times in lateral and anteroposterior direction for a couple of seconds. After removing the K-wires and guiding system, the stability of the fracture and the range of motion are tested, as is the position of the device (Figs. 2b, 3b, 4b). Finally the wound is closed using stitches (Fig. 5c).

Postoperative treatment and follow-up

Postoperatively the patients got a wrist splint for 5 days, to support wound healing. Immediate finger motion training was started postoperatively. Approximately 1 week (range 5–11 days) after surgery the first outpatient clinic control was performed. At that moment, anteroposterior and lateral radiographs were taken to control the position of the Micronail® (Figs. 2c, 3c, 4c). If there were no complications, load-carrying physical therapy with active range-of-motion exercises were started. Further follow-up took place at 6 weeks and 3–4 months after surgery at our outpatient clinic.

Fractures were classified according to AO principles [21]. Evaluation of clinical results 4 months after surgery was performed, using visual analogue scale (VAS score). We asked patients if they were satisfied regarding the function of their operated wrist. They had to indicate on an

analogue scale if they experienced the function of their operated wrist as bad, poor, average, good or excellent. We also looked at the range of motion of the operated wrist, comparing it with the contralateral one. We analyzed radiologic outcome with regard to union or occurrence of malunion. Also we looked at the position of the Micronail®, to see if there was angulation, inclination or shortening in length due to the operation.

Results

Mean operative time to position the Micronail® was 58 min, ranging from 41 to 106 min. Bilateral wrist fracture was operated in one setting, taking 106 min. Mean hospital stay was 7 days (range 1–28 days). The distribution of fractures according to the AO classification was as follows: 12 (60%) A2 fractures, 3 A3 (15%) fractures, 1 B1 fracture, and 1 B3 fracture. Three patients had an distal antebrachii fracture.

Eight patients had major associated lesions, not treated by Micronail®. One patient had a contralateral open communitive distal radius fracture, treated with external pin fixation. Two patients had a pubic arch fracture, treated nonoperatively. Two patients had a femoral neck fracture (Garden 1 and 2), both treated with dynamic hip screws (Synthes®). One patient had a intertrochanteric hip fracture, treated with a Gamma 3 intramedullary nail (Stryker®); one had a proximal femoral shaft fracture, treated with T2 femoral nail (Stryker®), and one had a fracture of the lateral tibial plateau, treated with LCP proximal tibia plate (Synthes®).

Eight wrists were treated postoperatively according to the standard guideline, consisting of 1 week cast splint. In the patients not treated by the standard guideline, eight wrists were treated with an extra 3 weeks circular cast, to support mobilization of associated injuries and thereby prevent overstraining of the site where the Micronail® was placed. Due to persisting pain sensation, two wrists were subsequently treated with 2 weeks soft cast. One wrist was subsequently treated with a pressure bandage because of surgical released carpal tunnel syndrome. One patient was treated with a circular cast for an additional 7 weeks because of secondary dislocation, which was corrected by closed reduction (Fig. 6a–e).

All fractures healed without major loss of alignment (<5° or 2 mm). The following postoperative complications were seen. Four postoperative complications occured. One patient developed a carpal tunnel syndrome, probably due to soft tissue swelling, which was surgically released. One osteosynthesis device secondary dislocated. After closed reduction the wrist was treated with circular cast. One patient developed cardiac decompensation and another patient a pneumonia. They both recovered uneventfully. No wound infections were reported. Postoperatively, none of the patients experienced or reported irritation of the ramus superficialis nerve.

The average period of follow-up was 4 months (range 3–6 months). At follow-up after 4 months, patients treated with the Micronail® experienced good to excellent results in function. Three patients experienced impaired wrist function compared with pretrauma status. Using the VAS score, patients had a pain sensation with mean score of 1.3 (range 0–3), meaning that they almost did not experience any pain. In the 15 patients who did not fracture both wrists (two were treated bilaterally, one with external pin fixation), the maximum difference in range of motion between the operated and nonoperated site was slight, being 0° up to a maximum of 10° in all motions. The average difference in range of motion was 4° (range 1–10°) in flexion, 3° (range 0–8°) for extension, 7° (range 6–10°) for radial deviation, 3° (range 1–10°) for ulnar deviation, 5° (range 3–8°) for pronation, and 5° (range 4–8°) for supination.

Discussion

There are a number of treatment options for distal radius fracture. Closed reduction and casting remains the standard of care in most fractures with minimal metaphyseal comminution and displacement of the articular surface. Although there is growing popularity for surgical treatment of distal radius fractures, a recent Cochrane database review does not provide robust evidence for this decision [14]. There is some evidence for the support of some treatment options, but their precise role is not established and nor are longer-term outcomes. A relatively new concept, in adults, is intramedullary fixation [22, 23].

Placement of the intramedullary Micronail® is minimally invasive and can be done by day-care surgery. This internal fixation method can be used in two-part extra articular and mildly displaced intra-articular distal radius fractures [24, 25]. We used the Micronail® to treat 20 distal radius fractures in 18 patients, of which the majority (60%) were type A2 distal radius fractures. Most patients (94%) were female, with mean age of 78 years. Although the Micronail® can be placed in one-day surgery, mean hospital stay was strangely enough 7 days. There are several reasons for this discongruency in admission time. First it could be due to the average age (78 years) and comorbidity (ASA score 2.4), which affect postoperative recovery. Second there were six patients with additional injuries (three hip fractures, one femoral shaft fracture, one tibial plateau fracture, one open communitive fracture of the radius) that needed operative treatment. Another reason for the prolonged stay in our hospital is the decreased self-help

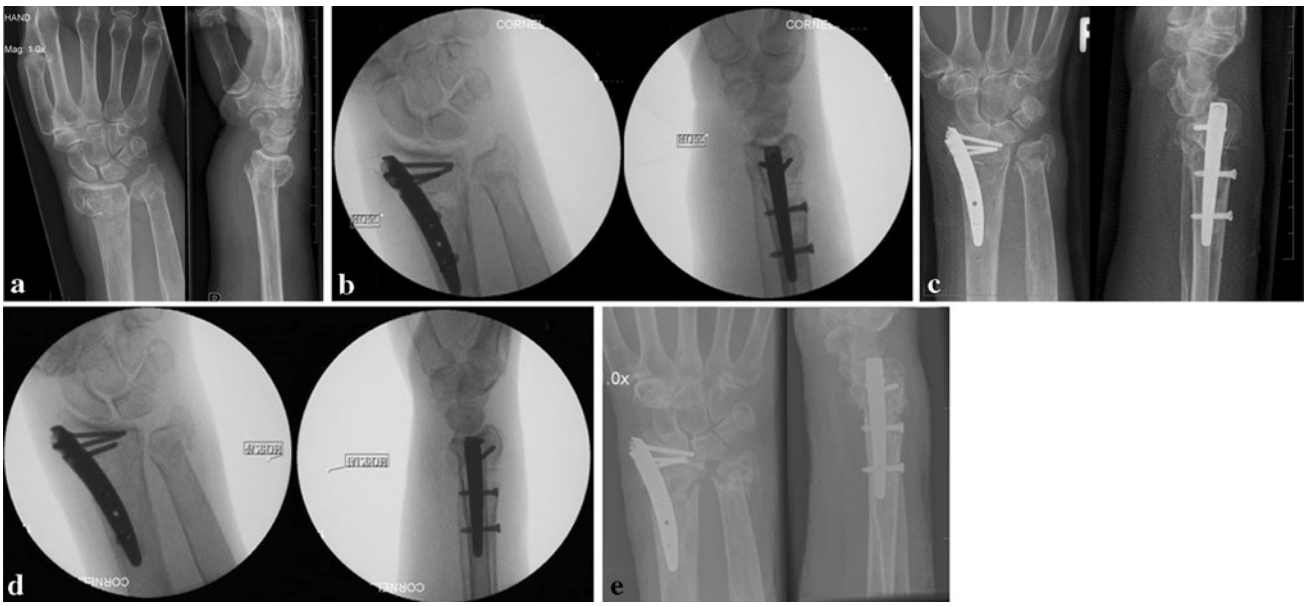

Fig. 6 **a** X-rays of a 76-year-old patient who fractured her distal radius on the right side. **b** Anteroposterior and lateral radioscopic view during surgery, after positioning the Micronail®. **c** Control X-ray of the wrist after 10 days of follow-up: a secondary dislocation can be seen. No evident trauma happened. **d** Anteroposterior and lateral radioscopic view during performance of closed reduction. **e** Control X-ray of the wrist after an additional 7 weeks of cast immobilization

capability and waiting list for a rehabilitation center or nursing home.

One of the major advantages of treating distal radius fracture with a Micronail® is that it allows removal of the cast and starting early load-carrying training of the wrist after 1 week. Casting has been associated with compressive neuropathies and complex regional pain syndrome [26]. It does not allow wrist mobilization, which may result in stiffness, muscle atrophy, and disuse osteopenia [27]. In our cohort, eight fractures (40%) could be treated with a cast for 1 week, followed by load-carrying exercises. Eight fractures had to be treated with an additional 3 weeks circular cast, to allow mobilization of associated injuries. Two patients had two extra weeks of soft cast due to pain.

Two wrist-related complications occurred. One patient developed a carpal tunnel syndrome. Final treatment was surgical release, followed by a wrist bandage. In another patient the Micronail® secondary dislocated, probably due to the osteoporotic status of the bones and the lack of cooperation due to the patient's mental status. Treatment was closed reduction and another 7 weeks of cast immobilization. Infection of the osteosynthesis materials, as often occurs in percutaneous or external fixation techniques, was not seen. Most fixators are transarticular, resulting in tissue irritation and finger motion problems secondary to tendon adhesion. Gripping activities may reduce, and fixating the wrist in flexion may even compress the median nerve. According to the patients' opinions and the VAS score, treatment by Micronail® was satisfactory. Patients experienced good to excellent function of their fractured wrist, and the pain sensation was low, with mean VAS score of 1.3. All patients experienced an almost full range of motion of their wrist. Radiologic results were also acceptable, without major loss of alignment (<5° or 2 mm).

Our results are comparable to the results of patients who underwent volar plating, considering ranges of motion, postoperative pain, and radiologic outcome [14, 16, 18, 20]. Complications in our series, as mentioned previously, also happen in series using volar plating [28].

The most important limitation to this study is that we describe a small sample size and that only eight patients underwent the standard postoperative treatment. This makes it less comparable with other techniques. Despite these limitations, we conclude that intramedullary implants tend to minimize some of the disadvantages of other surgical options in the treatment of distal radius fracture, causing less tissue damage and with early load-carrying capacity. With the use of the Micronail®, we found no infections or complications due to the insertion of the osteosynthesis materials. It seems that this minimally invasive technique is suitable in selected, two-part dislocated extra-articular and in mildly displaced intra-articular, distal radius fractures.

Conflict of interest statement None.

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